Area Traffic Control System (ATCS)

1. Introduction:

Area Traffic Control System is an indigenous solution for Indian Road Traffic, which optimizes traffic signal, covering a set of roads for an area in a city. It is an intelligent traffic signal control system that use data from vehicle detectors and optimize traffic signal settings in an area to reduce vehicle delays and stops.

The control system operates in real time with a capacity to calculate optimal cycle time, and feeds input to traffic signal controllers with a different set of stage timings. The timing plan of traffic controllers changed automatically to reduce stoppage time, which in turn reduces overall journey time.

The road traffic controllers can be connected to ATCS server thru' managed leased line network. Thus traffic monitoring over an area can be made possible from a central location. The system facilitates storing of traffic data for individual junctions over a period of days, including traffic pattern during peak hours, which enables traffic engineers to view and analyzing the same.

The original technology on ATCS was developed by Centre for Development of Advanced Computing (CDAC, Thiruvananthapuram), WML is manufacturing the same and have supplied more than 200 controllers in cities such as Pune, Jaipur, and Ahmedabad. The system supplied so far are working satisfactorily at different environmental condition, and hence filed proven.

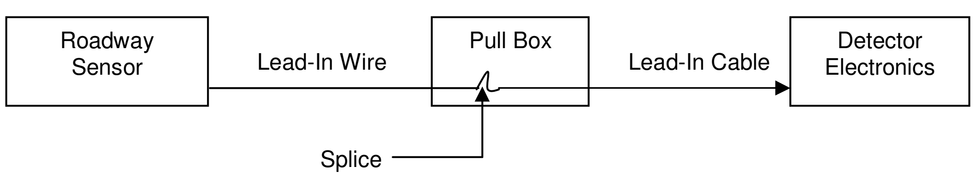
2. ATCS overview

The Major building blocks of the Area Traffic Control System are the following.

- Traffic Signal Controller
- Vehicle Detectors
- Communication Network thru' Leased Line
- Central Control System
- ATCS application software

2.1 Traffic Signal Controllers are the electronic equipment kept at the junction to control duration of traffic signals. The controllers are designed using microprocessor based control circuits, and can be operated with Fixed Time mode, Demand Actuated Mode, Forced Flash Mode etc.

2.2 The function of the Vehicle Detector is to identify the presence or passage of vehicles and provide input for traffic actuated signal control systems. Different type of vehicle detectors such as ultrasonic, microwave radar, magnetometer detector etc. is currently available. The most popular and economical one is the conventional inductive loop vehicle detectors.



Vehicle Detector System

The sensor loop is embedded on the pavement consisting of one or more turns of wire. Metallic parts of the vehicle resting or passing over the sensor loop will unbalance the tuned circuit (detector local oscillator) resulting in detection. The size, shape, and configuration of the loop vary considerably depending upon the specific application.

2.3 The communication network is the intermediate part which helps to communicate between the central control station and remote end junction controller. After analyzing the overall traffic flow in a corridor or a in a city the central control station updates the time plan to each and every junction controller through this UDP Internet Protocol based network communication link.

2.4 The Central control system (CCS) consists of ATCS Server, Operator Consoles, external storage device, projection system etc. All traffic signal controllers are connected to the CCS over managed leased line network at 64kbps.

2. The Network Control Strategy

Almost all the network solutions available for the ATCS are mathematical models. ATCS use a composite signal control strategy, CoSiCoSt, which is a hybrid of heuristic and mathematical approach.

2.1 Split Optimization

In CoSiCoSt, the split optimization is a two level strategy.

a. The Central Control (CC) suggests the stage timings to the intersection controller based on the demand trend analysis. This function is handled by the Split time modifier.
b. The traffic signal controller is given further autonomy to modify the split time online (Online Split Optimizer), within the constraint of common cycle time, by preempting stages of low demand and provide early start for the succeeding stage.

Sensor loops are provided for each approach at the stop-line. Wherever independent control is required for turning traffic, exit loops are provided. During red signal the detector will register a demand for a right of way. Towards the end of the initial green (mandatory minimum green), presence of the vehicle at the stop-line is verified by the traffic signal controller to decide for configurable extension or termination of the stage. For a presence, the green is extended for a programmable period. During the extended green the presence of vehicle is again checked for every second and appropriate extensions are given subject to the maximum green set for that approach. A non occupancy for a programmable period will preempt the current stage and start the next. The action described above is handled by the intersection controller.

Decision of the intersection controller to regulate the traffic could be compared with a Policeman (intelligent and impartial) controlling the junction. Once an approach is opened for right of way, he looks for a small gap (programmable in CoSiCoSt depending on the road geometry and flow conditions) in the flow. If the next vehicle is slightly behind the queue, he immediately terminates the signal and opens the other approach. This case he does not have a clear idea of the queue while opening the approach, but manages it with finding a gap.

A preempted signal will allow the next stage to have an early start. The succeeding stage will get a bandwidth of its maximum green plus the advantage of the early start. One or more approaches at an intersection carrying the maximum traffic will be identified as priority stage(s) by the system and the advantages of preemption will be enjoyed by this (these) stage(s). All these adjustments will be made by the intersection controller within the constraints imposed by the central control for proper coordination between other intersections in the network.

At every stage termination the intersection controller will report the current stage time settings for each approach and the actual demand during the stage execution to the Central Control. For example, if a stage set to execute 30 Seconds green, clears the traffic in 25 Seconds, it will preempt the stage at the 25^{th} second starting the next stage. At stage termination the controller will report that it has actually used only 25 seconds of green time against the set 30 seconds, to the CC. This is a feedback mechanism to check the effectiveness of the stage timings and cycle lengths set by CC. A preempted stage gives an indication that the queue is cleared. A stage executed for the full length or that uses only a small percentage of the set green will be flagged for modification, considering the traffic flow.

2.2. Managing Queues

A stage that record demand for the entire time allotted for it gives an indication of un-cleared queue at that approach. The CC flags such an incident and increase the stage time in finite steps till the queue is gracefully dispersed. Initial attempts will be made to accommodate the split time changes within the existing cycle length. If not possible, the cycle length itself will be modified to

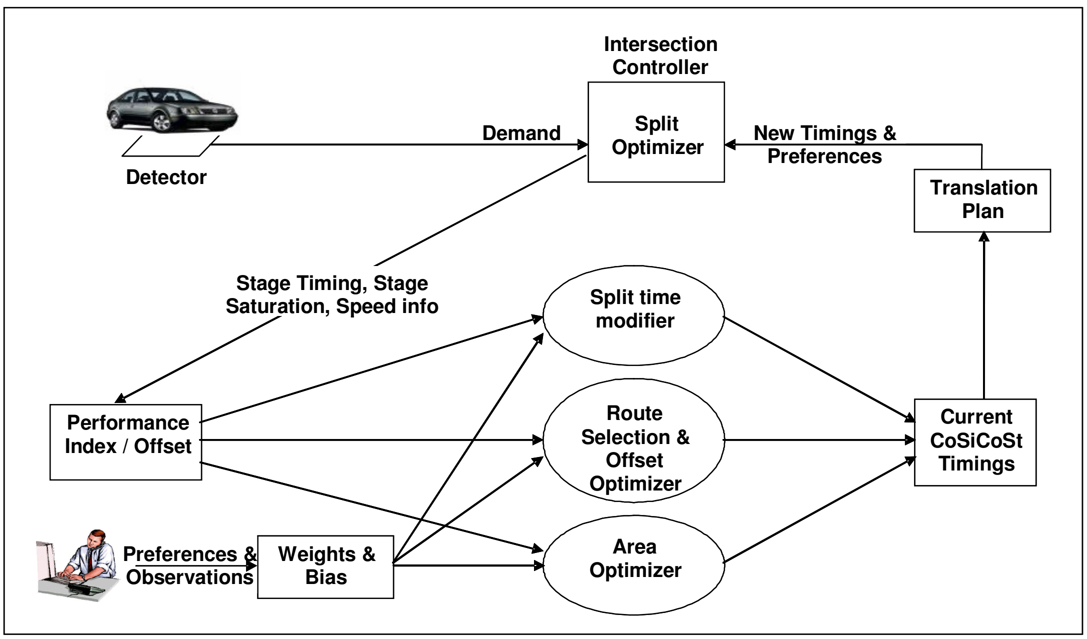


Figure 5: CoSiCoSt – Network Control Model

manage the queue. In either case care is taken to avoid cycle time oscillation and maintain signal coordination.

2.3. Area Optimization

Traffic volumes at different intersections are evaluated by the system to identify common cycle time zones. Intersections with more or less similar characteristics are grouped together considering their geographical distribution to operate on common cycle time. Junctions that make high disparity on the traffic volume are either isolated or accommodated in the group with half or double cycle time. Cycle time of the intersection that has maximum volume of traffic is considered as the critical cycle time and applied to the remaining intersections in the common cycle time zone. The cycle saturation is verified at every cycle. A highly saturated or poorly saturated cycle will be checked for consistency, and the cycle length modified as and when required.

The above explanations give an indication that some green time is wasted at less saturated intersection under the common cycle time zone. CoSiCoSt with its Online Split Optimizer module at the intersection controller efficiently manages this situation to reduce the green time wastage.

Routes that have maximum volume of traffic at a given point of time are identified as priority routes by the Central Control (CC). Stages contributing to the priority route are identified as priority stages and intimated the intersection controller by the CC. The intersection controller takes a strategy to preempt stages other than the priority stage and give all the advantage to the priority stage that handles the maximum volume of traffic at a given point of time.

2.4. Offset Optimization

CoSiCoSt is a traffic coordination system. It tries to identify arteries with maximum flow rate and provide coordinated traffic in these corridors. Coordination between the stages at different intersections is achieved by computing the ground speed of the platoon and displacing the stages with a definite offset. This technique is the offset optimization.

Sensor loops are provided at strategic locations and the flow profile is determined by the intersection controller for computing the ground speed. This is sent to the central control for computing and applying the offsets across the network to obtain maximum coordination between intersection controllers.

2.5. The Network Control

The task of network control is divided into the following.

a) Local optimization by the intersection controller

b) Network optimization by the central computer

Local optimization is achieved by the Online Split Optimizer module at the intersection controller. At the end of every stage the intersection controller reports the actually utilized green time, which is proportional to the average occupancy at each vehicle detector, along with its set maximum green for that stage to the central computer. Unless otherwise a change in cycle time or stage apportionment is required the central computer will not intervene in the operation of the intersection controller. A continuous occupancy during a green discharge gives an indication of un-cleared queue. On queue detection the central computer will verify whether it could be managed within the running cycle time by adjusting the stage distribution. This is possible if the cycle is not saturated. This case no change in the critical intersection or critical cycle is warranted. For a saturated cycle, incremental adjustments will be made in the succeeding cycles by the central control to disperse the queue gracefully. This case, the critical intersection and the common cycle time will be redefined. Similarly the cycle time and stage timings will be reduced in finite steps for under-saturated conditions, to reduce dead time.

Operating the intersections with 85% to 90% saturation is an accepted practice. This is to take care of transients. The Stage saturation is defined as a ratio of utilized green in an approach against its set green time. In CoSiCoSt though the stage settings are for 90% saturation, in real time they operate with 100% stage saturation on sub-links and the stage with maximum volume of traffic would get the advantage made at the sub-links by way of preemption. This ensures a smooth flow of traffic in the main corridors and no dead-time at the sub-links. Locally generated traffic in the main corridor could enjoy this additional bandwidth reducing the delay.

View from Control Room

ATCS Server

Center Control Room of Ahmedabad